CLAIMS

What is claimed is:

1. A radio communications system comprising:

an antenna array adapted to transmit and receive radio communications signals with a plurality of other terminals the communications signals each using a particular minimum bandwidth;

a transmit chain to transmit a calibration signal through the antenna array to a transponder;

a receive chain to receive through the antenna array a transponder signal from the transponder, the transponder signal being based on the calibration signal and having a bandwidth narrower than the minimum bandwidth; and

a signal processor to measure characteristics of the transponder signal as received through the receive chain.

2. The system of claim 1, wherein the calibration signal has a bandwidth narrower than the minimum bandwidth.

3. The system of claim 1, wherein the transponder signal is reduced in carrier bandwidth and converted in frequency as compared to the calibration signal.

4. The system of claim 1, wherein the measured characteristics of the transponder signal include phases and amplitudes.

5. The system of claim 4:

wherein the receive chain comprises a plurality of receive chains;

wherein each receive chain receives the transponder signal; and

wherein the signal processor determines a receive calibration vector by comparing the phases and amplitudes of the transponder signal as received by each receive chain.

6. The system of claim 5 wherein the signal processor determines the receive calibration vectors by forming a vector whose complex elements have phases and amplitudes corresponding to the relative difference in phase and amplitude of the channels from each receive chain.

7. The system of claim 5, wherein each receive chain comprises a receive channel from an antenna to the conversion to a digital representation of the received signal.

8. The system of claim 5, wherein one of the plurality of receive chains is selected as a reference chain and the complex elements of phase and amplitude of the receive calibration vector for the reference chain are set equal to one.

9. The system of claim 5, wherein the receive calibration vector is formed by averaging several receive calibration vectors.

10. The system of claim 5 wherein the signal processor determines a transmit calibration vector using measured phases and amplitudes of several receptions of the transponder signal.

11. The system of Claim 4 wherein the signal processor determines an uplink signature of the transponder at the antenna array using the measured phases and amplitudes of the transponder signal.

12. The system of Claim 11 wherein the signal processor further determines a receive calibration vector for the receive chain using the uplink signature of the transponder.

13. The system of Claim 4 wherein the signal processor determines a downlink signature of the transmit chain at the transponder using the measured phases and amplitudes of the transponder signal.

14. The system of Claim 13 wherein the signal processor further determines a transmit calibration vector for the transmit chain using the downlink signature of the transmit chain.

15. The system of claim 1:

wherein the transmit chain comprises a plurality of transmit chains;

wherein each transmit chain transmits the calibration signal; and

wherein the signal processor determines a downlink signature of the transmit chain at the transponder by comparing the calibration signal from each transmit chain as reflected in the measured characteristics of the transponder signal.

16. The system of claim 15, wherein the calibration signal comprises a plurality of signals, one from each transmit chain, each signal being individually identifiable based on a unique spreading function.

17. The system of claim 15, wherein the calibration signal comprises a plurality of signals, one from each transmit chain, each signal being individually identifiable based on a unique modulation sequence.

18. The system of claim 15, wherein the measured characteristics of the transponder signal include phases and amplitudes and wherein the signal processor determines a transmit calibration vector by forming a vector whose complex elements have phases and amplitudes corresponding to the relative difference in phase and amplitude of the channels from each transmit chain.

19. The system of Claim 15 wherein one of the plurality of transmit chains is selected as a reference chain and the complex elements of phase and amplitude of the transmit calibration vector defined with reference to the reference chain.

20. The system of claim 15, wherein the transmit calibration vector is formed by averaging several transmit calibration vectors.

21. The system of claim 1, wherein the antenna array includes a plurality of antennas each of which transmits and receives signals.

22. The system of claim 1, wherein the antenna array includes a first plurality of antennas for transmitting the calibration signal and a second plurality of antennas for receiving the transponder signal.

23. The system of claim 22:

wherein each antenna has a corresponding transmit chain and a corresponding receive chain;

wherein each transmit chain transmits the calibration signal;

wherein each receive chain receives the narrowband transponder signal based on the transmitted calibration signal; and

wherein the signal processor determines a transmit calibration vector by comparing the calibration signal from each transmit chain as reflected by the measured characteristics and determines a receive calibration vector by comparing the transponder signal received at each receive chain as reflected by the measured characteristics.

24. The system of claim 23, wherein the calibration signal is transmitted substantially simultaneously from each transmit chain.

25. The system of claim 23, wherein the receive calibration vector and the transmit calibration vector are determined based on the same transponder signal reception.

26. The system of claim 1, wherein the antenna array, receive chain and transmit chains are components of a code division multiple access cellular communications system.

27. A method comprising:

transmitting a calibration signal from an antenna array, the antenna array being adapted to transmit and receive radio communication signals each using a particular minimum bandwidth;

receiving a transponder signal at the antenna array, the transponder signal being based on the calibration signal and having a bandwidth narrower than the minimum bandwidth; and

measuring characteristics of the transponder signal as received through the receive chain.

28. The method of claim 27, further comprising generating a calibration vector using the measured characteristics.

29. The method of claim 27, further comprising generating a transmit calibration vector by comparing the transponder signal as received by the individual elements of the transmit antenna array using the measured characteristics.

30. The method of claim 27, wherein transmitting comprises transmitting a calibration signal having a bandwidth narrower than the minimum bandwidth using the antenna array.

31. The method of claim 27, wherein the transponder signal is frequency shifted in comparison to the calibration signal.

32. The method of claim 27, wherein each antenna has a corresponding transmit chain and a corresponding receive chain, wherein transmitting comprises transmitting the calibration signal from each transmit chain, wherein receiving comprises receiving the transponder signal at each receive chain, and further comprising determining a transmit calibration vector by comparing the calibration signal from each transmit chain as received as a transponder signal by each receive chain.

33. The method of claim 27, wherein the calibration signal is transmitted substantially simultaneously from each transmit chain.

34. The method of claim 28 further comprising generating a transmit calibration vector using the measured characteristics of the transponder signal as received by individual antenna elements.

35. The method of claim 34, further comprising generating a receive calibration vector by comparing the measured characteristics of the transponder signal as received by the individual antenna elements.

36. The method of claim 27 further comprising determining a spatial signature for the transponder signal using the measured characteristics as received through the receive chain.

37. The method of claim 36 wherein determining a spatial signature comprises determining an uplink spatial signature by comparing the transponder signal as received by each receive chain.

38. The method of claim 36, wherein determining the spatial signature comprises forming a vector whose complex elements have phases and amplitudes corresponding to the relative difference in phase and amplitude of the channels from each receive chain.

39. The method of claim 36, further comprising determining calibration vectors for the receive chain and the transmit chain using the spatial signature.

40. The method of claim 36, wherein the spatial signature is formed by averaging several spatial signatures.

41. A calibration transponder for use in a radio communications system comprising:

a receive antenna to receive a wideband calibration signal from a system to be calibrated;

a bandpass filter to convert the wideband calibration signal into a narrowband signal; and

a transmit chain including a transmit antenna to transmit the narrowband signal to the system to be calibrated.

42. The transponder of claim 41, wherein the calibration signal is a spread spectrum signal, the transponder further comprising a filter to convert the spreading code of the calibration to a different spreading code.

43. The transponder of claim 41, further comprising a mixer to convert the frequency of the calibration signal to a different frequency before transmitting.